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GUNNER ERRORS WHEN USING THE M72A2 LAW SIGHT

Dominick J. Giordano

August 1975  
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U. S. ARMY HUMAN ENGINEERING LABORATORY  
Aberdeen Proving Ground, Maryland

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## 20. Abstract (Continued)

mock-up in the correct manner to achieve a hit. Targets were announced as either stationary or moving. Subjects who had received the refresher training were significantly more accurate in the performance tasks, and expressed more confidence in their ability to use the M72A2 sight effectively, than the subjects who had not; however, even the subjects who had received additional training made a substantial number of serious errors. It is concluded that the human performance tasks necessary to use the M72A2 LAW sight are complicated enough that inadequately trained gunners will make frequent and sizeable errors, thus significantly reducing the battlefield effectiveness of the LAW weapon system. Recommendations are proposed for improving training in these tasks.

GUNNER ERRORS WHEN USING THE M72A2 LAW SIGHT

Dominick J. Giordano

Professional Assistance

John L. Miles

Technical Assistance

William Sember

August 1975

APPROVED: 

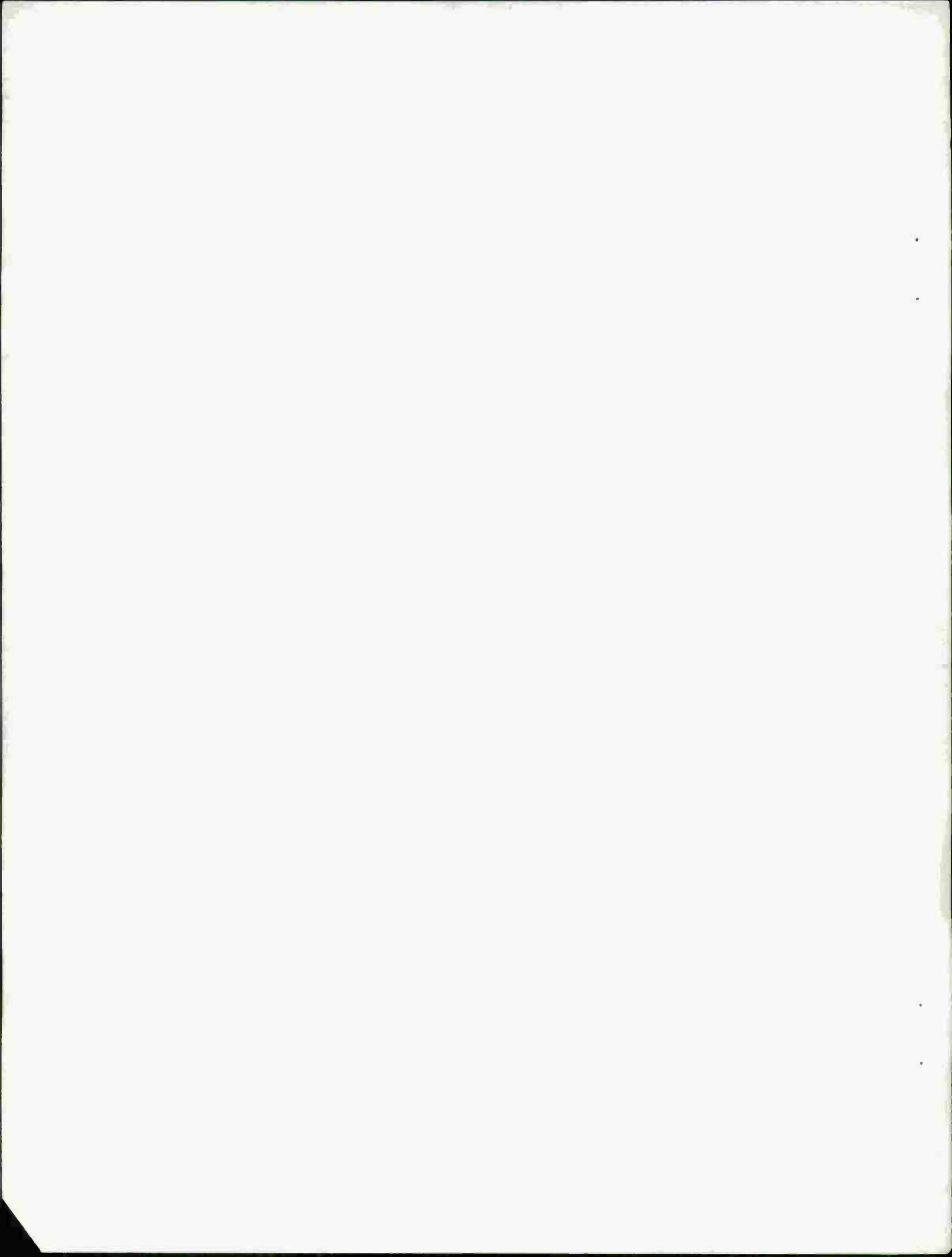
JOHN D. WEISZ

Director

U. S. Army Human Engineering Laboratory

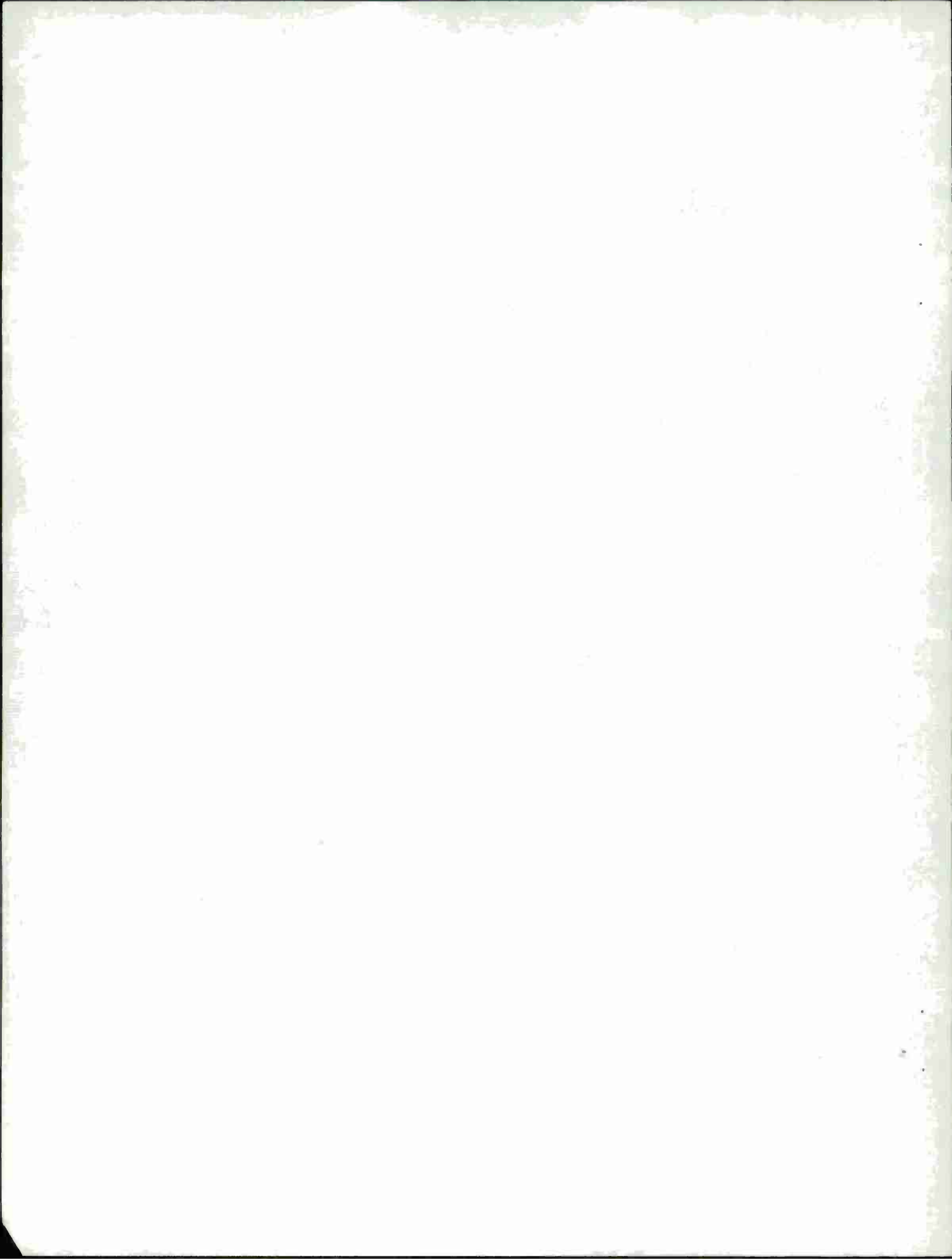
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Aberdeen Proving Ground, Maryland



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## GUNNER ERRORS WHEN USING THE M72A2 LAW SIGHT

### INTRODUCTION

#### Background

Observations of infantry subjects participating in recent antitank weapon investigations indicate that the present training in the use of the M72A2 (LAW) sight which the typical infantryman receives in basic combat training (BCT) and advanced individual training (AIT) may not adequately prepare future LAW gunners to use the sights effectively. In a U. S. Army Human Engineering Laboratory (HEL) experiment (2) to measure the effectiveness of stadia sights, 20 infantry subjects who had received training with the LAW in BCT, AIT or Vietnam, claimed to know how to use stadia lines. However, a training portion of the experiment revealed that none of the soldiers understood completely how to use the stadia correctly.<sup>1</sup> More recently, during an HEL experiment to measure operational setup time for the LAW (which was conducted as a subexperiment of a body armor/equipment interface experiment), discussions with some of the subjects indicated that their knowledge of the use of stadia was marginal. Their lack of knowledge was surprising in view of the fact that they were recent AIT graduates who had passed their LAW proficiency tests. This, and the pretest performance of the subjects in the previous experiment, suggested that either the subjects' training in the use of the LAW or their retention of the information presented in training was inadequate—or both. To validate these observations, it was decided to test this group of subjects' knowledge of the use of the M72A2 LAW sight.

Shortly after this testing was completed, a separate experiment was conducted by the Infantry Board at Fort Benning to measure the baseline performance of the LAW (7). As part of that experiment, the test soldiers received refresher training in the use of the weapon sight. Personnel from HEL and U. S. Army Ballistic Research Laboratories, who observed portions of that experiment, informally interviewed five of the test soldiers with regard to use of the weapon sight. Their findings were that, even after refresher training, three of the five soldiers interviewed did not fully understand how to use the sight.<sup>2</sup> Following recommendations made by these observers, HEL repeated the previous test with this group of test soldiers at the conclusion of the LAW baseline performance experiment.

Subsequently, another field experiment with the LAW was conducted by the Infantry Board at Fort Benning, this time to test the hypothesis that increased training would improve gunner's performance with the LAW (6). Test conditions were identical to the LAW baseline performance experiment except the test soldiers received additional training in the use of the weapon sight. Once again, at the conclusion of this experiment, the test soldiers participated in the HEL experiment (which tested their knowledge of the weapon sight).

Thus this report analyzes the performance of three groups of subjects, each with increasing levels of training in the use of the LAW sight.

---

<sup>1</sup>Unfortunately, pretraining performance of the subjects was not measured.

<sup>2</sup>Portions of a trip report describing details of the test and the subject interviews are contained in Appendix B.

## The Stadiametric Sight and Its Problems

The use of the M72A2 stadiametric sight is described in FM 23-33 (3). More complete explanations and descriptions of stadiametric principles are given in FM 23-80 (4) and FM 23-81 (5). In general, when ranging with the stadia:

1. A head-on target is positioned in the half-stadia—between either the left or right stadia line and the centerline in the sight.
2. A side-on target is positioned in the full stadia—between the left and right stadia lines.
3. For targets at intervening aspects, the gunner should select the half stadia if the apparent width of the target exceeds its apparent length, and the full stadia if the apparent width is greater.

Obviously, gunners can (and do) make mistakes in choosing between half- and full-stadia ranging. If the gunner uses full stadia when he should use half-stadia ranging, there will be a large overestimate of range. For the opposite situation, there will be a large underestimate of range.

The gunners can also make other kinds of errors and, in addition, there are a number of error sources that can bias range measurements. These are described in Appendix A and shown in Figures 1A and 2A.

The sight on the M72A2 LAW is a typical stadia sight—it contains stadia lines, range lines and lead lines. When the M72 was first fielded, the sight contained only range lines and lead lines. Stadia lines were added during product improvements of the weapon, in the belief that they would help the gunner determine range to primary (tank) targets. However, the validity of this belief has been undermined by at least five factors:

1. The stadia in the M72A2 LAW sight are designed to maximize accuracy for a specific size of target—10 x 20 feet—whereas typical tank targets are larger.
2. Even if the target has the same dimensions for which the stadia are designed, the gunner may see it at an aspect other than head-on or side-on, where the reference dimensions do not apply.
3. Measurements made at HEL show that the sight radius assumed in designing the stadia lines is in error by about 5 percent. Consequently, range measurements will contain this 5 percent error.
4. Since there are stadia lines only between 135 and 350 meters, the gunner must employ other techniques to estimate the range to targets closer or further away.
5. There is a conceptual difference between the sight designer and the trainer about details of how gunners should use the stadia correctly; as a result, gunners consistently underestimate ranges (4).

## METHOD

### Purpose

The purpose of the experiment was to determine (1) how well infantrymen recently trained in the use of the M72A2 LAW sight could use stadia lines to estimate range to tank targets and use the lead lines to lead moving targets, and (2) the likely sources of gunner errors.

### Subjects

The first group of subjects was composed of 29 recent AIT graduates who were participating in field tests conducted by HEL at Aberdeen Proving Ground. They were tested without any additional LAW training.

The second group of subjects was composed of 16 infantrymen who had just participated in field tests of the LAW conducted by the Infantry Board at Fort Benning (6). This group had, in addition to BCT and AIT LAW training, just received refresher training as prescribed in Army Subject Schedule 23-74, and they had each fired approximately 14 rounds at stationary and moving targets at various ranges during the Infantry Board field test.

The third group of subjects was composed of 19 infantrymen who had just participated in a second field test of the LAW conducted by the Infantry Board at Fort Benning (7). The conduct of this field test was similar to the previous one, except that the gunners received more extensive training in the use of the LAW, and each had fired a total of 16 training rounds and 13 HE rounds in the course of the Infantry Board test.

### Apparatus

The ability of the subjects to use the sight was measured with an (approximately) 8:1 scale mock-up of an M72A2 front sight reticle, consisting of a clear plexiglass overlay containing range, stadia and lead lines. The sight reticle is shown in Figure 1. The mock-up sight used in testing the first two groups of subjects differed from the one used in testing the third group of subjects. The first mock-up sight contained .5 mm wide reticle markings that were scribed by hand onto the plexiglass. The second mock-up sight was made using a photographic enlargement of the M72A2 LAW sight reticle and a silk-screen process. The reticle markings were 3 mm wide. There was a minor variation in the scale of the two mock-ups.

The sight mock-up was used with 8-inch by 10-inch color photographs of an M60A2 tank. The photographs showed the tank in different sizes (representing different ranges) and aspects. Four photographs, showing the tank head-on, side-on, and quartering, were used in testing the first two groups of subjects. An additional four photographs, showing a frontal and flanking tank, were used in testing the third group of subjects. Figure 2 shows the tank at the five different aspects (but not the relative size) used in the experiment. A discussion of the correct placement of targets in the stadia and the kinds of errors that gunners can make is contained in Appendix A.



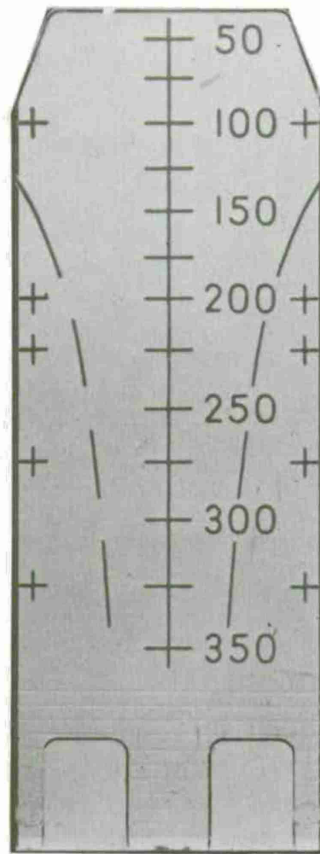


Figure 1. M72A2 sight reticle.

The tank sizes in the photographs were scaled so that Target 3 was at a range too far for the stadia, and Target 7 was at a range too close for the stadia. In other words, there were no stadia lines for these targets' scaled ranges. The other targets were scaled at different ranges within the range limits of the stadia.

Targets 1 and 3 (side-on) and Target 2 (head-on) represented targets at "ideal" aspects, exactly side-on and exactly head-on. Target 4 was at an intermediate aspect where subjects could correctly use either half or full stadia. Because none of the subjects tested in the first two groups elected to use the half stadia to measure the target's range, targets at other aspects were included in the testing of the third group of subjects. The objective here was to determine how well the subjects used the stadia for targets that were not at ideal aspects.



Targets 1 and 3, Side-on



Targets 5 and 8, Frontal



Targets 6 and 7, Flanking



Target 2, Head-on



Target 4, Quartering

Figure 2. Target tank at five different aspect angles.

## Procedure

The subjects were interviewed one at a time, and each was asked the 14 questions shown in Tables 1 through 3. The interviewer recorded the subjects' responses on these data sheets. Questions 1 through 12 solicited information on the subject's LAW training, his present theoretical knowledge, and his confidence in his ability to use the sight correctly. Questions 13 and 14 were the performance test in which the subject was required to place the sight mock-up on each of the photographs in the correct manner to: (1) measure the range to the target, and (2) to achieve a hit on the target.

The purpose of this experiment required that all subjects must have undergone the LAW training prescribed for BCT and AIT. Consequently, subjects in Group 1 who had not received LAW training (as determined by their responses to question 3) were eliminated from further testing.

At the end of the first part of the interview (questions 1 through 12), the use of the mock-up was explained to the subjects, and then the second part of the interview was conducted. The photographs were presented to the subjects one at a time, and the subjects were instructed to place the overlay over the target in accordance with the instructions (shown in questions 13 and 14). The photographs were first described as representing stationary targets, then as representing moving targets. The procedures used to determine range to stationary and moving targets were identical. To lead the moving targets, the subject would slide the overlay to the proper position on the tank after he had determined its range. With the first group of subjects, interviewers measured and recorded only the range at which the targets was placed in the sight. This procedure was used because the subjects had difficulty interpolating range between range marks on the sight and in addition, different subjects apparently selected different points on the target from which to determine range (some selected the turret ring, some a point near the target center of mass, and others, an indeterminate point somewhere between the top and bottom of the tank). With the second group of subjects, two observations—the range at which the target was actually placed in the sight, and the range the subject called—were recorded. The interviewer also noted the method—half or full stadia—selected by a subject to range to the target, and the position of the target with respect to the stadia lines. Either an incorrect selection of half or full stadia to estimate range to the range, or a large gap between the edges of the tank and the edges of the stadia lines was interpreted as indicating that a subject did not know how to use the stadia correctly.

## RESULTS

The results of the experiment are tabulated in Tables 1, 2, and 3 respectively, for the three groups of subjects. Tables 1C, 2C and 3C list the range-measurement errors with the sight mock-up. The distribution of the range-measurement errors for the stationary target test condition is shown in Figures 3, 4, 5, and 6.

Tables below questions 13 and 14 in Tables 1, 2, and 3 show the range-measurement error means and standard deviations, expressed as a percentage of true range, for two sample sizes. The larger sample size includes all of the subjects tested in each group, whereas the smaller sample excludes those gunners who made gross errors (e.g., using half stadia when full stadia was required). The types and numbers of errors made by the subjects when attempting to lead moving targets are shown below the aforementioned tables.



TABLE 1

## Summary of Results - Group 1

## INTERVIEWER'S DATA SHEET: M72 Sight Usage

Date: 13-17 May 1974Name and Rank: 29 - E2Place: APG, MDNumber: 29 Enlisted Infantrymen

1. Where did you receive basic training? 22 - Ft. Leonardwood; 7 - Ft. Ord  
 When? Nov 1973

2. Where did you receive AIT? 29 - Ft. Polk  
 When? Feb 1974 What MOS? 11B

3. Approximately how many hours of M72 (LAW) training did you receive in basic? In AIT?

	Basic	AIT	Both	Neither
Number	28	9	9	1
Mean Hours	7	4		

4. a. Did you receive instruction in how to put the LAW into operation?  
28 - Yes

b. How many times did you practice putting the LAW into operation?  
Mean = 10

5. a. Did you receive instruction in how to use the range lines in the sight reticle? 96% (27) - Yes

b. Do you know how to use them now? 78% (23) - Yes

6. a. Did you receive instruction in how to use the stadia lines in the sight reticle? 96% (27) - Yes

b. Do you know how to use them now? 83% (24) - Yes

7. a. Did you receive instruction in how to lead a moving target?  
96% (27) - Yes

b. Do you know how to lead a moving target now? 78% (23) - Yes

8. a. Did you do any dry firing? 96% (27) - Yes

b. Did you use the range lines 73% (21) and/or the stadia 54% (16) ?

TABLE 1 (Continued)

9. a. How many practice rounds did you fire (if any)?

86% (25) - Yes    Mean Rounds - 4

b. From what firing position? Majority of rounds fired from standing position.

c. At what kinds of targets? 100% (25) Tanks

How far were the targets? Median - 250 meters. Range - 75 to 300 meters.

d. Which technique did you use to find the range to the target?

Known range \_\_\_\_\_ Visual range estimation \_\_\_\_\_ Stadia \_\_\_\_\_

Majority of rounds were fired at known range targets and the gunners were instructed to verify the range with the stadia.

e. Did you hit the target(s)? 92% (23 of 25) - Yes

10. a. How many live rounds did you fire (if any)? 3 - Yes. Numbers of rounds were 3, 2 and 1, respectively.

b. From what firing position? Standing and kneeling.

c. At what kinds of targets? 2 Tanks; 1 Bunker. What ranges? 150 - 350 meters.

d. Which technique did you use to aim at the target?

Known range \_\_\_\_\_ Visual range estimation \_\_\_\_\_ Stadia \_\_\_\_\_

As in 9d.

e. Did you hit the target(s)? 100% (3) - Yes

11. For what sizes of targets can you use the stadia lines to estimate range?

	Tanks	10'x20'	Both	Don't know
Percent (gunners)	55%(16)	7%(2)	7%(2)	45%(13)

12. For the following targets, would you use the stadia lines to estimate range or would you visually estimate range and use the range lines?

	Jeep	Bunker	Tank	Truck	Troop Emplacement
Stadia	29%(8)	36%(10)	79%(22)	68%(19)	29%(8)
Visual	71%(20)	64%(18)	21%(6)	32%(9)	71%(20)



TABLE 1 (Continued)

13. Here is an enlarged LAW sight reticle and some pictures of a tank. Pretend you are using the stadia to range and to bring fire upon a stationary tank. Using the stadia lines, show me how you would determine the range to the tank, tell me the range, then show me where you would be aiming at the tank when you fired.

NOTE: Three subjects reported that they did not know how to use the stadia.

	True Range	Range Error--Percent of True Range		
		Placed		
		N	Mean	S.D.
a. Side-on	300	13 25	-1.3 -12.7	4.8 14.4
b. Head-on	210	18 25	-3.1 25	5.8 44.6
c. Side-on	350+ (Out of Range)	12 25	-2.4 -15.9	3.5 15.1
d. Quarter	240	17 25	-2.6 -7.8	3.7 23.4

14. Now let's pretend that the tank is moving at 15 miles per hour.

	True Range	Range Error--Percent of True Range		
		Placed		
		N	Mean	S.D.
a. Side-on	300	14 25	-1.9 -16.6	4.4 19.4
b. Head-on	210	8 25	-3.1 24	8.8 44.5
c. Side-on	350+ (Out of Range)	13 25	-1.6 -17.7	3.1 19.4
d. Quarter	240	19 25	-2.1 -3.2	4.1 22.3

TABLE 1 (Continued)

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Lead Errors	
a. Side-on	<p>Correct Lead--Right side lead line on leading edge of tank</p> <p>Errors--5, no lead  8, right side lead line on trailing edge of tank  8, right side lead line on center of tank  1, center line on leading edge of tank</p>
b. Head-on	<p>Correct Lead--None</p> <p>Errors--None</p>
c. Side-on	<p>Correct Lead--As in "a" above</p> <p>Errors--6, no lead  8, right side lead line on trailing edge of tank  7, right side lead line on center of tank</p>
d. Quarter	<p>Correct Lead--Right side lead line approximately midway  between leading edge and center of tank</p> <p>Errors--10, no lead  3, right side lead line on leading edge of tank  1, right side lead line on trailing edge of tank</p>

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TABLE 2

## Summary of Results - Group 2

## INTERVIEWERS DATA SHEET: M72 Sight Usage

Date: 29 May 1974 Name and Rank: 

Rank	E1	E2	E3	E4
Gunners	1	5	6	4

Place: Ft. Benning, GA Number: 16 Enlisted Infantrymen

1. Where did you receive basic training? Eight different Posts--largest number, four at Ft. Knox.

When? 1968 to 1973 Median of 1973

2. Where did you receive AIT? Five different Posts--largest number, ten at Ft. Polk.

When? 1968 to 1973 What MOS? 

MOS	11B	11H
Gunners	11	5

  
Median of 1973

3. Approximately how many hours of M72 (LAW) training did you receive in basic? In AIT?

	Basic	AIT	Both	Neither
Number	9	7	2	2
Mean Hours	12	7		

4. a. Did you receive instruction in how to put the LAW into operation in basic? 9 - Yes In AIT? 7 - Yes
- b. How many times did you practice putting the LAW into operation in basic? Mean = 8 In AIT? Mean = 3
5. a. Did you receive instruction in how to use the range lines in the sight reticle in basic? 100% (9) - Yes In AIT? 100% (7) - Yes
- b. After the instruction, did you know how to use the range lines? Basic 67% (6) - Yes AIT 100% (7) - Yes
- c. Do you know how to use them now? 100% (16) - Yes
6. a. Did you receive instruction in how to use the stadia lines in the sight reticle in basic? 89% (8) - Yes In AIT? 100% (7) - Yes
- b. After the instruction, did you know how to use the stadia lines? Basic 100% (8) - Yes AIT 100% (7) - Yes
- c. Do you know how to use them now? 100% (16) - Yes

TABLE 2 (Continued)

7. a. Did you receive instruction in how to lead a moving target in basic? 89% (8) - Yes In AIT? 71% (5) - Yes
- b. After the instruction, did you know how to lead a moving target? Basic 100% (8) - Yes AIT 100% (5) - Yes
- c. Do you know how to lead a moving target now? 100% (16) - Yes
8. a. Did you do any dry firing in basic? 7 - Yes In AIT? 5 - Yes  
In both? 0 - Yes

- b. Did you use the range lines 50% or the stadia 50% ?

9. a. How many practice rounds did you fire (if any) in basic? In AIT?

	Basic	AIT
Gunners	6	2
Mean Rounds	3	1&20

- b. From what firing position? Majority of rounds fired from standing position.

- c. At what kinds of targets? 100% - Tanks

How far were the targets? Median - 250 meters. Range - 100 to 300 meters

- d. Which technique did you use to find the range to the target?

Known range 25% (2 of 8) Visual range estimation 0%

Stadia 75% (6 of 8)

- e. Did you hit the target(s)? 63% (5 of 8)

10. a. How many live rounds did you fire (if any) in basic? In AIT?

	Basic	AIT
Gunners	4	5
Median Rounds	3	3

- b. From what firing position? Majority of rounds fired from standing position.

- c. At what kinds of targets? 100% - Tanks

What ranges? Median - 250 meters. Range - 150 to 300 meters.

TABLE 2 (Continued)

d. Which technique did you use to aim at the target?

Known range 11% (1 of 9) Visual range estimation 11% (1 of 9)

Stadia 67% (6 of 9)

e. Did you hit the target(s)? 78% (7 of 9)

11. For what sizes of targets can you use the stadia lines to estimate range?

	Tanks	10'x20'	Both	Don't Know
Percent (gunners)	50% (8)	25% (4)	13% (2)	13% (2)

12. For the following targets, would you use the stadia lines to estimate range or would you visually estimate range and use the range lines?

	Jeep	Bunker	Tank	Truck	Troop Emplacement
Stadia	81%(13)	75%(12)	94%(15)	94%(15)	25%(4)
Visual	19%(3)	25%(4)	6%(1)	6%(1)	75%(12)

13. Here is an enlarged LAW sight reticle and some pictures of a tank. Pretend you are using the stadia to range and to bring fire upon a stationary tank. Using the stadia lines, show me how you would determine the range to the tank, tell me the range, then show me where you would be aiming at the tank when you fired.

Range Error--Percent of True Range							
	True Range	Called			Placed		
		N	Mean	S.D.	N	Mean	S.D.
a. Side-on	300	13	-6.9	4.1	13	-3.0	3.5
		16	-9.5	11.3	16	-7.9	10.4
b. Head-on	210	10	-6.2	4.7	10	-6.5	2.9
		16	8.3	29.6	16	11.3	31.7
c. Side-on	350+ (Out of Range)	11	0.4	4.0	-	-	-
		16	-4.7	13.7	-	-	-
d. Quarter	240	14	-3.3	4.5	14	-0.6	2.7
		16	-7.2	11.5	16	-3.7	8.9

TABLE 2 (Continued)

14. Now let's pretend that the tank is moving at 15 miles per hour.

		Range Error--Percent of True Range						
		True Range	Called			Placed		
			N	Mean	S.D.	N	Mean	S.D.
a.	Side-on	300	13	-4.3	4.9	13	-2.9	2.6
			16	-9.2	11.5	16	-7.2	16.3
b.	Head-on	210	10	-6.0	5.8	10	-6.0	4.9
			16	8.2	31.0	16	12.0	33.0
c.	Side-on	350+ (Out of Range)	11	0.4	2.5	-	-	-
			16	-6.2	18.4	-	-	-
d.	Quarter	240	14	-2.8	4.8	14	-0.6	3.6
			16	-7.2	12.8	16	-5.1	13.2

#### Lead Errors

- a. Side-on Correct Lead--Right side lead line on leading edge of tank.  
Errors--5-Right side lead line on center of tank.
- b. Head-on Correct Lead--None.  
Errors--None.
- c. Side-on Correct Lead--As in "a"  
Errors--6-Right side lead line on center of tank.  
1-No lead.
- d. Quarter Correct Lead--Right side lead line approxi-  
mately midway between leading edge and  
center of tank.  
Errors--1-Right side stadia line on leading edge of tank.  
1-No lead.

TABLE 3

## Summary of Results - Group 3

## INTERVIEWER'S DATA SHEET: M72 Sight Usage

- Date: 11 Oct 74 Name and Rank: 

Rank	E2	E3	E4	E5
Gunners	8	4	4	3
- Place: Ft. Benning, GA Number: 19 Enlisted Infantrymen
1. Where did you receive basic training? 

10	Ft. Jackson	4	Ft. Polk
3	Ft. Dix	2	Ft. Knox
- When? 1963 to 1974 Median of 1973
2. Where did you receive AIT? 

15	Ft. Polk	2	Ft. Benning
1	Ft. Campbell	1	Ft. Jackson
- When? 1964 to 1974 What MOS? 100% - 11B  
Median of 1974
3. Approximately how many hours of M72 (LAW) training did you receive in basic? In AIT?
- |            | Basic | AIT | Both | Neither |
|------------|-------|-----|------|---------|
| Number     | 10    | 8   | 4    | 4       |
| Mean Hours | 4     | 4   |      |         |
4. a. Did you receive instruction in how to put the LAW into operation in basic? 6 - Yes In AIT? 8 - Yes
- b. How many times did you practice putting the LAW into operation in basic? Mean = 5 In AIT? Mean = 5
5. a. Did you receive instruction in how to use the range lines in the sight reticle in basic? 70% (7) - Yes In AIT? 75% (6) - Yes
- b. After the instruction, did you know how to use the range lines?
- Basic 43% (3) - Yes AIT 83% (5) - Yes
- c. Do you know how to use them now? 100% (19) - Yes
6. a. Did you receive instruction in how to use the stadia lines in the sight reticle in basic? 50% (5) - Yes In AIT? 63% (5) - Yes
- b. After the instruction, did you know how to use the stadia lines?
- Basic 60% (3) - Yes AIT 100% (5) - Yes
- c. Do you know how to use them now? 100% (19) - Yes



TABLE 3 (Continued)

7. a. Did you receive instruction in how to lead a moving target in basic? 60% (6) - Yes AIT? 63% (5) - Yes
- b. After instruction, did you know how to lead a moving target? Basic 83% (5) - Yes AIT? 100% (5) - Yes
- c. Do you know how to lead a moving target now? 100% (19) - Yes
8. a. Did you do any dry firing in basic? 40% (4) - Yes  
In AIT? 63% (5) - Yes  
In both? 2 - Yes
- b. Did you use the range lines 33% or the stadia 67% ?
9. a. How many practice rounds did you fire (if any) in basic? In AIT?
- |             | Basic | AIT |
|-------------|-------|-----|
| Gunners     | 3     | 4   |
| Mean Rounds | 2     | 4   |
- b. From what firing position? Majority of rounds fired from standing position
- c. At what kinds of targets? Majority of targets tank and APC hulls, 1 tank silhouette, 1 moving target  
How far were the targets? Median - 200 meters  
Range - 100 to 350 meters
- d. Which technique did you use to find the range to the target?  
Known range 43% (3 of 7) Visual range estimation 29% (2 of 7)  
Stadia 29% (2 of 7)
- e. Did you hit the target(s)? 43% (3 of 7)
10. a. How many live rounds did you fire (if any) in basic? In AIT?
- |             | Basic | AIT | Both |
|-------------|-------|-----|------|
| Gunners     | 2     | 5   | 2    |
| Mean Rounds | 1     | 2   |      |
- b. From what firing position? Majority of rounds fired from standing position
- c. At what kinds of targets? 100% - Hulls What ranges? Median - 200  
Range - 150 to 250



TABLE 3 (Continued)

d. Which technique did you use to aim at the target?

Known range 60% (3 of 5) Visual range estimation 20% (1 of 5)

Stadia 20% (1 of 5)

e. Did you hit the target(s)? 80% (4 of 5)

11. For what sizes of targets can you use the stadia lines to estimate range?

	10' x 20'	10'	20'	Other
Percent Gunners	<u>57% (11)</u>	<u>11% (2)</u>	<u>11% (2)</u>	<u>21% (4)</u>

12. For the following targets, would you use the stadia lines to estimate range or would you visually estimate range and use the range lines?

	Jeep	Bunker	Tank	Truck	Troop Emplacement
Stadia	<u>42% (8)</u>	<u>58% (11)</u>	<u>100% (19)</u>	<u>84% (16)</u>	<u>26% (5)</u>
Visual	<u>58% (11)</u>	<u>42% (8)</u>	<u>0% (0)</u>	<u>16% (3)</u>	<u>74% (14)</u>

13. Here is an enlarged LAW sight reticle and some pictures of a tank. Pretend you are using the stadia to range and to bring fire upon a stationary tank. Using the stadia lines, show me how you would determine the range to the tank, tell me the range, then show me where you would be aiming at the tank when you fired.

	True Range	N	Mean	S.D.
1. Side-on	<u>215</u>	19	- .3	4.0
2. Head-on	<u>225</u>	19 16	0.5 -2.9	18.3 5.2
3. Side-on	<u>350+</u>	19 14	3.7 0.0	7.7 4.8
4. Quartering	<u>280</u>	19 18	-1.5 -0.3	7.0 4.7
5. Frontal	<u>210</u>	19 16	-10.0 -22.0	29.4 9.0
6. Flanking	<u>160</u>	19	0.8	5.7
7. Flanking	<u>100</u>	19 17	- .7 -1.1	12.8 9.4
8. Frontal	<u>320</u>	19	-15.0	13.4

TABLE 3 (Continued)

14. Now let's pretend that the tank is moving at 15 miles per hour

	<u>True Range</u>	<u>N</u>	<u>Mean</u>	<u>S.D.</u>
1. Side-on	<u>215</u>	<u>19</u>	<u>0.7</u>	<u>3.4</u>
2. Head-on	<u>225</u>	<u>19</u> <u>14</u>	<u>7.2</u> <u>-2.5</u>	<u>24.6</u> <u>3.6</u>
3. Side-on	<u>350+</u>	<u>19</u> <u>11</u>	<u>-0.6</u> <u>1.2</u>	<u>17.3</u> <u>4.3</u>
4. Quartering	<u>280</u>	<u>19</u> <u>18</u>	<u>-3.1</u> <u>-0.4</u>	<u>12.5</u> <u>4.4</u>
5. Frontal	<u>210</u>	<u>19</u> <u>11</u>	<u>16.0</u> <u>-13.4</u>	<u>39.9</u> <u>20.6</u>
6. Flanking	<u>160</u>	<u>19</u>	<u>1.0</u>	<u>6.1</u>
7. Flanking	<u>100</u>	<u>19</u> <u>15</u>	<u>-1.8</u> <u>1.0</u>	<u>13.2</u> <u>6.8</u>
8. Frontal	<u>320</u>	<u>19</u>	<u>-9.7</u>	<u>14.8</u>

#### Lead Errors

1. Side-on Correct Lead--Right side lead line on leading edge of tank.  
Errors: 2, center line on leading edge of tank.  
6, right side lead line on center of tank.
2. Head-on Correct Lead--None.  
Errors: 2, center line on edge of tank (target not centered).  
2, right side lead line on edge of tank.
3. Side-on Correct Lead--As in "1" above.  
Errors: 1, center line on leading edge of tank.  
2, right side lead line on center of tank.
4. Quartering Correct Lead--Right side lead line approximately midway between left edge and center of tank.  
Errors: 5, right side lead line on leading edge of tank.  
2, center line on center of tank.

TABLE 3 (Continued)

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5. Frontal	Correct Lead--Center line on left edge of tank. Errors: 13, center line on center of tank (no lead). 3, right side lead line on center of target.
6. Flanking	Correct Lead--Right side lead line on center of tank. Errors: 11, right side lead line on left edge of tank. 1, left side lead line on left edge of tank.
7. Flanking	Correct Lead--As in "6" above. Errors: 8, right side lead line on left edge of tank. 2, left side lead line on left edge of tank.
8. Frontal	Correct Lead--As in "5" above. Errors: 12, center line on center of tank (no lead). 2, right side lead line on center of tank. 2, center line on right (trailing) edge of tank.

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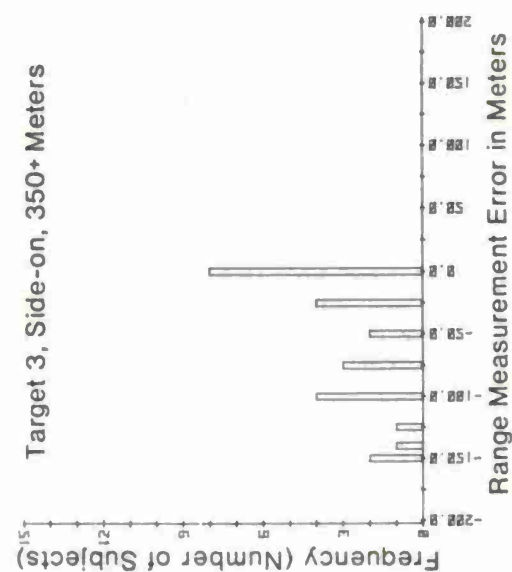
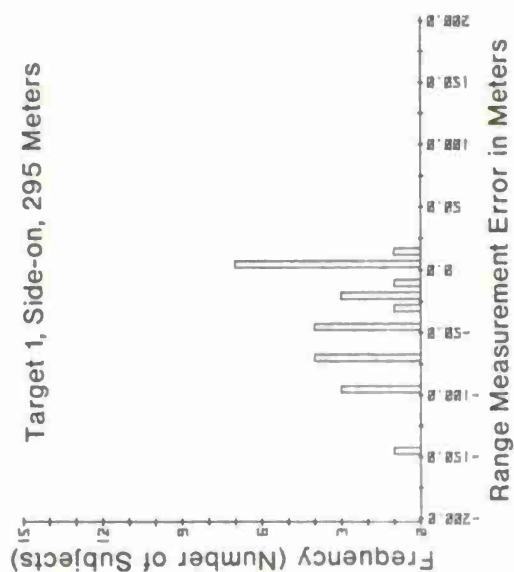
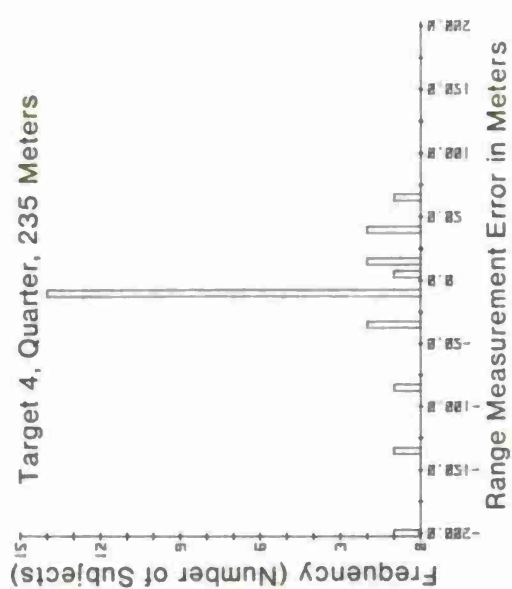
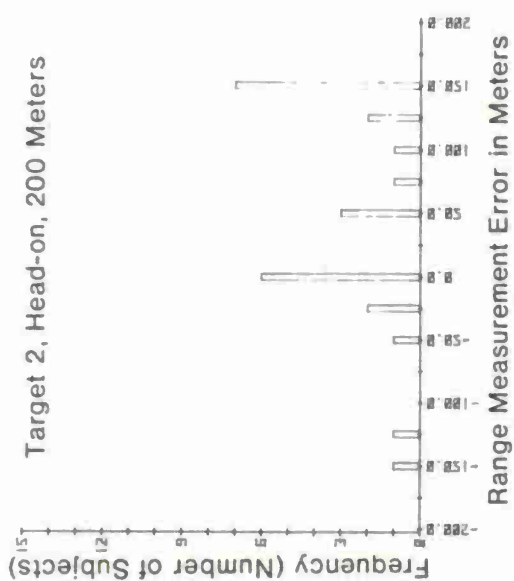


Figure 3. Distribution of range-measurement errors—Group 1, stationary targets.

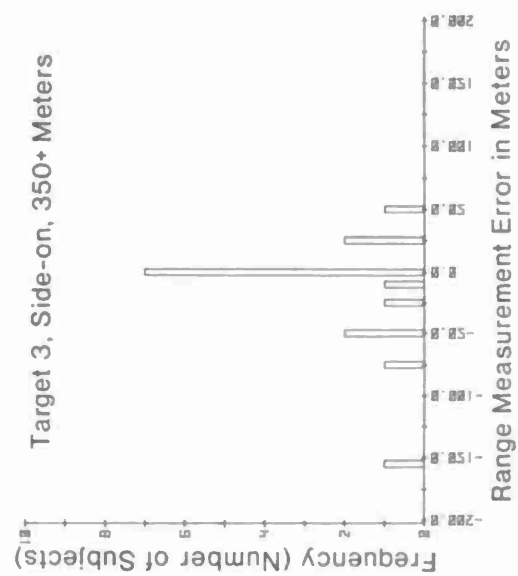
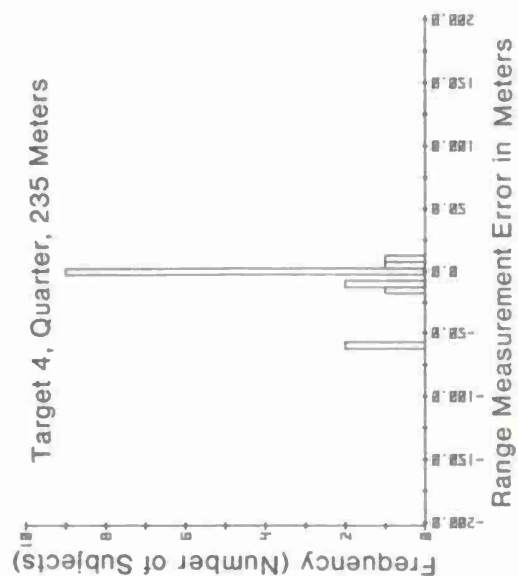
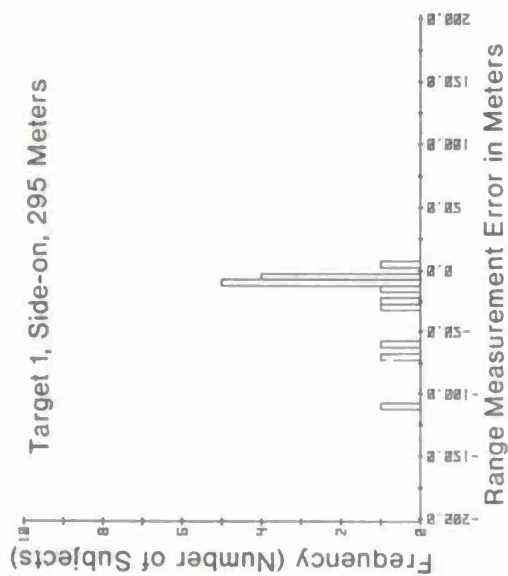
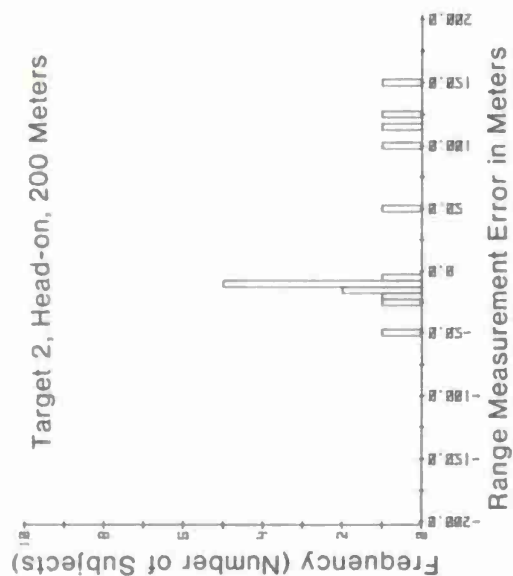


Figure 4. Distribution of range-measurement errors—Group 2, stationary targets.

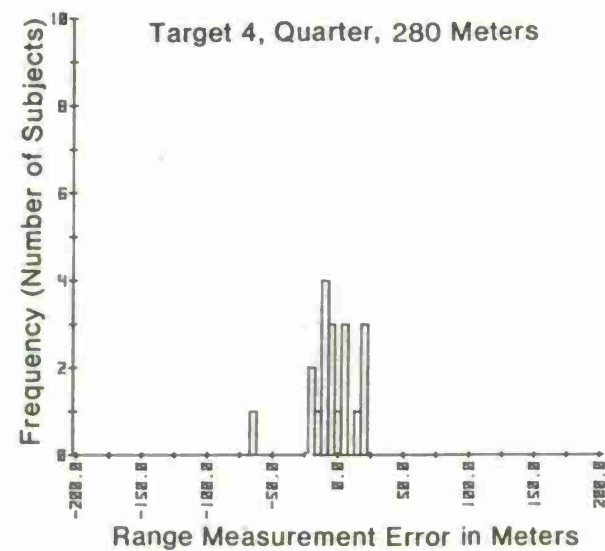
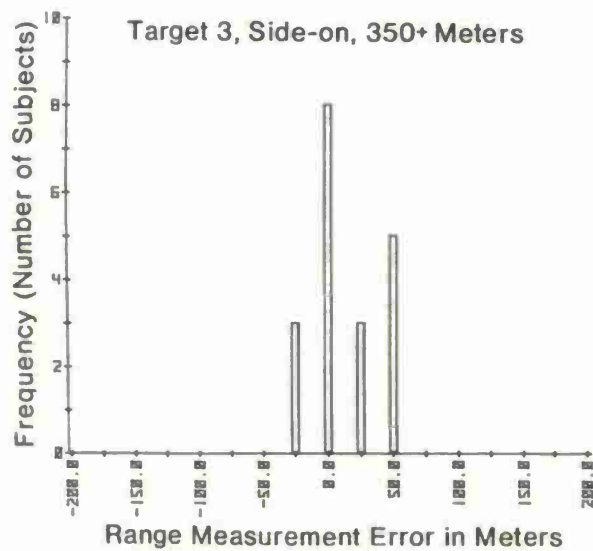
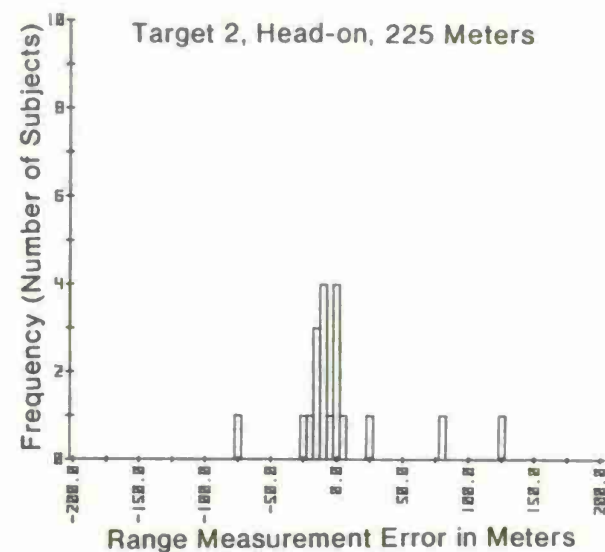
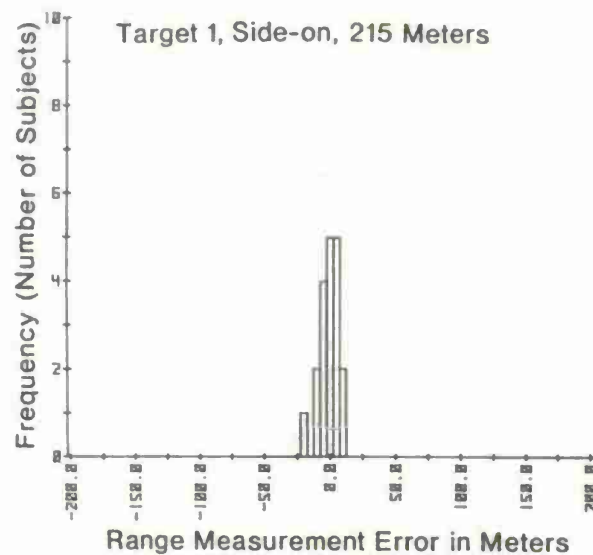


Figure 5. Distribution of range-measurement errors—Group 3, stationary targets 1 through 4.

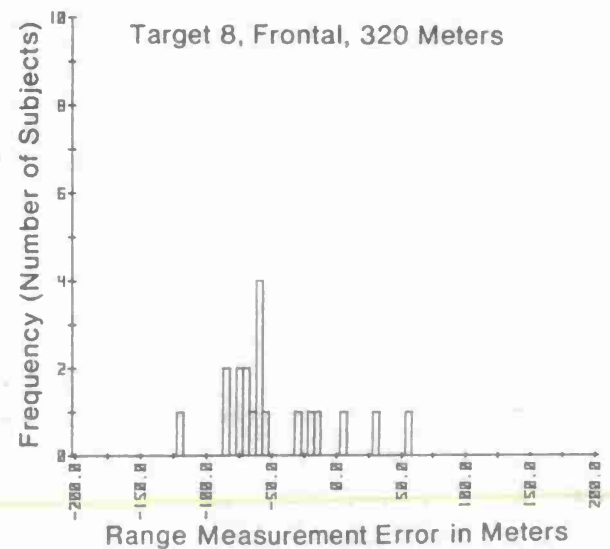
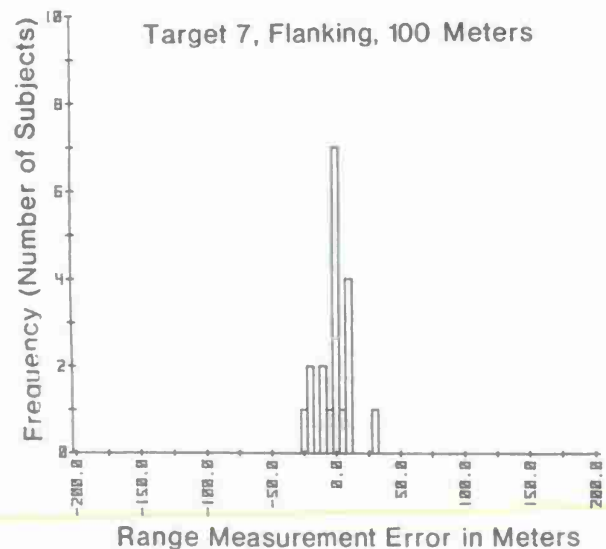
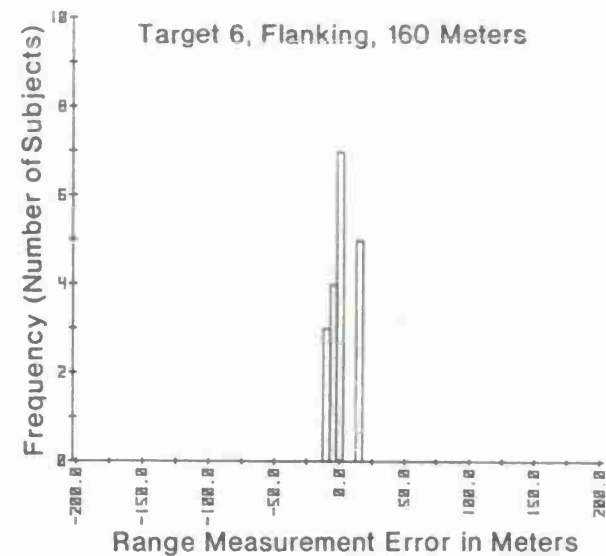
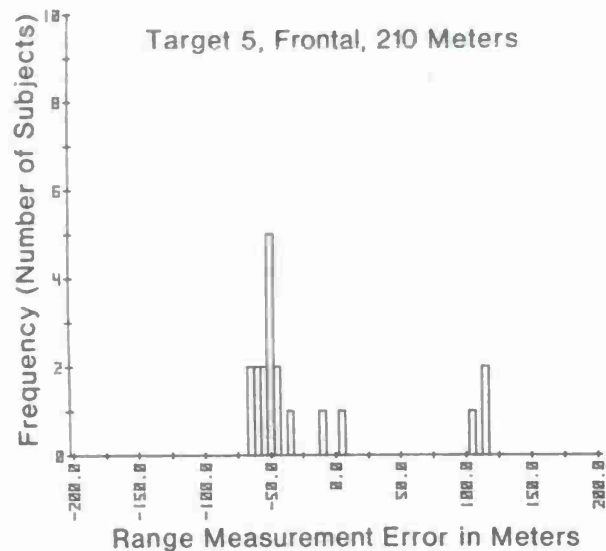


Figure 6. Distribution of range-measurement errors—Group 3, stationary targets 5 through 8.



In general, the ability of the subjects in each group to use the weapon sights paralleled the amount of training they had received with the LAW.

### Group 1

In the first group of subjects interviewed, one had not received training with the LAW, and one, although having been trained with the LAW, had not received (or did not remember) training in the use of the sight. Therefore, only 27 soldiers were asked questions 5 through 10. The responses to questions 5 through 8 showed that 96 percent of the soldiers had received training in the use of the stadia lines, range lines and lead lines contained in the sights. Of those, 78 percent stated that they still knew how to use them. However, the responses to questions 12 through 14 indicated otherwise. Almost half of the subjects did not know the sizes of targets for which stadia could be used to obtain range (question 11). Furthermore, when asked to select between stadia ranging and unaided visual range estimation for specific targets (question 12), 29 percent of the subjects answered incorrectly that the stadia could be used to range to a troop emplacement.

Twenty-seven subjects had received training with the stadia lines and lead lines ("yes" answer to questions 6a and 7a, respectively), but only 26 and 23 subjects, respectively, reported that they could still use them ("yes" answer to questions 6b and 7b). Of the 26 subjects who attempted to use the mock-up, one reported that he could not, so that ranging performance could be measured validly only for 25 subjects.

Almost half of the 25 subjects tested with the sight mock-up were judged not to know how to range to a side-on target with the full stadia. For head-on targets, where half-stadia ranging was required, more than 75 percent of the subjects incorrectly placed the target somewhere within the full stadia. Similar results were obtained for moving targets (question 14), and most of the gunners were judged not to know how to lead a moving target.

### Group 2

The second group of subjects, having just received additional training in the use of the LAW sight, performed significantly better than the first group. All of the subjects claimed that they could use the range lines, stadia lines, and lead lines in the sight. However, two of the subjects stated that they did not know the sizes of targets for which the stadia could be used, and four subjects answered incorrectly that stadia could be used to range to a troop emplacement. When actually using the mock-up to estimate range to the targets, three of the subjects (29 percent) used the full stadia incorrectly with side-on targets, and six of the subjects (37 percent) estimated range incorrectly with head-on targets. Only a few errors were made in leading moving targets—usually by applying too little lead (Fig. 4).

Subjects in these two groups who used the stadia correctly (or almost correctly) tended to place the target above the stadia lines (i.e., they left a gap between the stadia lines and the edges of the target). This resulted in a mean range underestimation, which is shown in Tables 1 and 2 for the smaller sample size. The subjects who made errors in estimating range to head-on targets usually positioned the target within the full stadia at a range much greater than the true target range. This resulted in a large mean overestimation of target range which is shown in Tables 1 and 2 for the larger sample size. The frequency and magnitude of these errors can be seen in Figures 3 and 4.



We must note that it was impossible to determine the range to the third target with the stadia; thus the subject's correct response should have been that the target was at some unknown range beyond 350 meters. In group 1, one subject responded correctly, but the other 17 subjects estimated ranges closer than 350 meters. Three of the subjects in group 2 positioned the target beyond the 350-meter maximum-range line in the sight reticle.<sup>3</sup>

### Group 3

The third group of subjects, which had received the greatest amount of training with the LAW, made the fewest mistakes. Some had not received LAW training in BCT and AIT and, once again, there were a number of subjects who were unsure of how to use the sight.

Four of the 15 subjects had not received training with the LAW in either BCT or AIT. Of the 15 who had, nearly 75 percent had been instructed in how to use the range lines, and slightly more than half were instructed in how to use the stadia lines and how to lead moving targets. After receiving additional training at Fort Benning, all of the subjects were confident of their ability to use the sight. However, four of the gunners (question 11) were still unsure of the sizes of targets for which the stadia could be used, and these four, plus one other subject, believed incorrectly (question 12) that the stadia could be used to measure range to a troop emplacement.

When Group 3 used the mock-up sight to estimate range to the first four targets—the same targets used in testing the first two groups of subjects—the Group 3 subjects made errors similar to those the second group of subjects made. However, the magnitude of the errors was smaller. This can be seen by comparing Tables 2C and 3C and the range error tables shown in Tables 2 and 3. For the two flanking targets, the errors were similar to those for the other target aspects—side-on and quartering—where full-stadia ranging was required. However, when subjects had to estimate ranges for targets that were not exactly head-on—namely, the two frontal targets—only one subject was judged to know how to place the target correctly within the stadia.

For the frontal targets, most of the subjects placed the entire vehicle, instead of its frontal portion, within the half-stadia (as explained in Appendix A). This resulted in a mean underestimation of range for the frontal targets, which is shown in Table 3. The frequency and magnitude of these errors are shown in Figure 6.

With respect to lead errors, the third group of gunners was able to lead the first four targets more accurately than the other groups of subjects. Most of the gunners, however, made errors in leading targets five through eight: the frontal and flanking targets.

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<sup>3</sup>This may have reflected the training received in the Fort Benning experiment, where the subjects were instructed to aim at a 400-meter target by positioning the 350-meter range line at the top of the target.

## DISCUSSION

In troubleshooting a military weapon system, human factors engineers customarily examine four distinct, but interacting, factors:

1. The human performance requirements.
2. The abilities the operator (gunner) must possess.
3. The type and amount of training necessary to achieve reliable human performance.
4. The design of the equipment in the man-machine interface.

The scope of this experiment included only the first and third factors. It was primarily concerned with determining on a gross level whether the performance deficiencies of LAW gunners (observed in previous tests) could be attributed to inadequate training, or whether the aiming tasks themselves are too demanding and need to be simplified.<sup>4</sup>

Although all of the subjects were alert and cooperative, many of them were unable to master the intricacies of using the sight. The subjects in Group 1, who had recently graduated from infantry AIT, usually proved unable to use the M72A2 weapon sight correctly. One might presume that, given more intensive training, the soldiers would perform better. This presumption is at least partially accurate, as evidenced by the improved performance of the second and third groups of subjects who, while participating in the Fort Benning experiments, had received intensive training with the sight and had fired about 14 and 29 rounds, respectively, at varied targets: head-on and side-on, stationary and moving. However, even in Groups 2 and 3—apparently well-trained gunners—there were some who did not know how to use the sight correctly, especially for targets which required half-stadia ranging. In Group 1, we believe that the test subjects' deficient performance arose mostly from inadequate training in BCT and AIT and from the vague explanation of how to use the weapon sight given in FM 23-33 (which is the guideline for sight training in Army Subject Schedule 23-74).

However, we must also account for the unsatisfactory performance of subjects in the groups which had the additional training. There are at least two tenable explanations:

1. The particular program of LAW training presently used by the Army is inadequate.
2. There are a significant number of persons whose aptitudes, though within the limits specified for MOS 11B, are insufficient to permit them to master the intricacies of the aiming tasks for the M72A2 LAW.

It should be obvious that the implications of the second alternative are considerably more far-reaching and costly than those of the first. Consequently, a closer examination of the present LAW training is clearly the first step.

Only a small amount of time is allocated to sight training in Army Subject Schedule 23-74, and the training schedule does not include instruction in methods of estimating range other than with stadia.

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<sup>4</sup>For example, an analysis may show that the most cost-effective way to improve man-weapon system performance is to redesign the equipment, rather than to train longer or more extensively.

FM 23-33 (July 1970) describes how to use the LAW sights—but not completely enough because it gives only one ranging method: using the stadia. It does not give the procedures gunners should use when targets are too close for the stadia, or when targets are out of range. Paragraph 25c states that "In general, to sight the launcher the gunner must first estimate the range to the target with the stadia lines" and that "Using the sight on the M72A1/M72A1E1 is the same as with the M72 except that stadia lines have been added to aid the gunner in estimating range to targets of known dimensions; e.g., a tank, or a truck." However, the use of the M72 sight is assumed, not described; in Appendix E, only a picture of the sight is shown. Paragraph 36 states that the weapon can be used for targets other than armored vehicles, and paragraph 37 says that the weapon may be employed against grouped or attacking personnel.

In reading paragraph 25c, one must ask what is meant by "in general"? And when is it inappropriate to range with the stadia lines? For example, how do gunners interpolate between stadia lines when target dimensions differ greatly from those of a tank (e.g., a bunker 15 feet in diameter)? And, does paragraph 37 mean to imply (by omission) that the stadia can be used to range to personnel?

A more thorough description of the method of employing stadia for estimating range, and a description of the principle upon which stadia range measurement is based, are given in FM 23-80 (October 1952) and FM 23-81 (November 1952). These publications also mention the use of range cards and visual range estimation—though only briefly.

From the foregoing, there seems to be promise of improving LAW gunner performance by restructuring the training problems along these lines:

1. Improve the description of how to use stadia and specifically delimit the target sizes and types for which stadia are appropriate. This information should be added to FM 23-33 and Army Subject Schedule 23-74. Most important, the training manual should clearly tell when to use the stadia for range estimation and when to use alternate methods. For target ranges less than 135 meters, where there are no stadia lines, and for targets whose dimensions differ greatly from those of a tank, the range should be estimated without using the stadia—for example, by unaided range estimation or by using range cards.

2. Explain the limitations of estimating range by stadia, and especially the degradation that occurs when the stadia are used incorrectly.

3. Instruct the trainees in using visual range estimation and range cards when the stadia cannot be used, or when they are unsure of how to use the stadia.

The trainees should be tested in using stadia with photographs and a plexiglass sight mock-up, similar to the ones used in this experiment. When the trainees are taken to the range for live firing (or firing with the training round), each trainee should make three estimates of the target range; first, using unaided visual range estimation; second, using the stadia; and third, using a previously prepared range card which shows the gunner's location and the paced-off distances to at least two prominent terrain features near the target. These three estimates should be compared and discussed, and the true target range should be revealed to the gunner before he fires the first round. Thus the trainee would have feedback regarding his ability to use the three methods to determine range, and the limitations of each method.



This additional training would no doubt require somewhat longer time training with the LAW. However, considering the unsatisfactory level of proficiency shown by infantrymen tested in the experiments, increased training appears warranted.

If, after such training, a significant number of infantrymen are still unable to perform the aiming tasks to a satisfactory standard, consideration should be given to redesigning the sight to simplify the tasks.

The sight redesign proposed here consists simply of eliminating the stadia lines. It is possible that improved training in the use of the stadia may substantially improve the operator's ability to use them accurately. Nevertheless, indications are that the gunner's overall performance will still not be substantially better than the accuracy that they could achieve with simple visual range estimation. Supporting this contention are the results of the two Fort Benning tests, using the latter two groups of more experienced gunners. The recorded hit probabilities in both tests were very similar to the theoretical hit probabilities for gunners using visual range estimation (i.e., range-estimation error whose standard deviation is 21 percent of range). Reasons for the poor performance of stadia sights in general, and the M72A2 stadia sights in particular, are presented in the introduction and in Appendix A.

Proving (or disproving) this redesign's effectiveness would require a field experiment to measure the performance of gunners using both unmodified LAWs, and LAWs with modified sight reticles containing the same range and lead markings, but without the stadia lines.

## RECOMMENDATIONS

1. Infantrymen should receive more extensive training in using the M72A2 LAW weapon sight than they are receiving in BCT and AIT. The training should be broadened to include a better explanation of how stadia are used to measure target range, the limitations of stadia for ranging, and when and how to use alternatives to stadia, such as unaided visual range estimation and range cards. Because the best way to improve tactical LAW performance is to estimate ranges more accurately, emphasis should be placed on preparing range cards—pacing off (or measuring with some device) the distance to prominent terrain features—wherever possible, especially when in the defensive role.

2. A field experiment should be conducted to compare the performance of gunners firing the M72A2 LAW using stadia versus unaided visual-range estimation, to determine whether more extensive training in the use of stadia actually improves gunner performance. The results of this experiment might show that the most effective way to improve the gunner's performance is merely eliminating the stadia lines in the sight, and training the gunners to use other ranging methods, i.e., unaided visual-range estimation and range cards.

## CONCLUSIONS

Almost three-quarters of a group of soldiers who were recently trained to use the LAW sight, in either or both BCT and AIT, did not know how to use the stadia. Furthermore, a majority of soldiers in two other groups, who had received extra training with the LAW sight, in addition to BCT and AIT, still made many mistakes in using the stadia. These findings clearly indicate that either:

1. The training was not adequate for the present-day population of infantry troops, or
2. The stadia sight demands very precise (skilled) performance that clearly exceeds the abilities of a significant proportion of infantrymen.

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## APPENDIX A

### SOURCES OF RANGE-MEASUREMENT ERROR WITH STADIA

There are many sources of range-measurement error with stadia. The sources of error described herein can be separated into three categories; the first is shown in Figure 1A, and the other two are given in Figure 2A.

Three components of range-measurement error, which we shall call "components of normal range-measurement error", are shown in Figure 1A. Full-stadia ranging to side-on targets is shown on the left side of the figure, and half-stadia ranging to head-on targets is shown on the right side of the figure. Starting at the top of the figure, we have a stationary tank target with a two-to-one length-to-width ratio, and stadia lines with an infinitesimal line thickness. The target, as shown here, is correctly positioned in the stadia at a range, "a". The stadia lines, however, actually have a finite thickness; although the stadia are designed assuming that a gunner fits the target to the centers of the lines, Army doctrine requires the gunner to fit the target to the inside edges of the lines. This source of error, shown as "component 1" in the figure, causes the gunner to underestimate the range to the target. As shown, the range-measurement error is greater for head-on targets than for side-on targets.

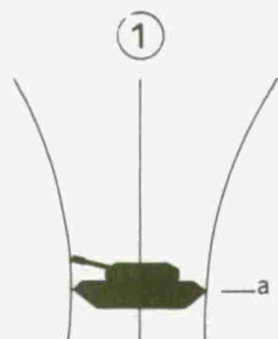
For a hand-held weapon, there is a component of aiming error (sometimes called "holding error") caused by the gunner's unsteadiness. The effect of the gunner's unsteadiness, shown as "component 2" in the figure, is an apparent reduction in the separation between the stadia lines which, in turn, causes an underestimation of target range. Because reducing the separation between the stadia lines is analogous to increasing the stadia line thickness, we see that once again the resultant error is greater for head-on than for side-on targets.

Movement of the target causes a third component of error, which is similar to component 2. For a side-on target, the fact that the gunner must track the target increases his unsteadiness. Also, dirt clouds and exhaust fumes mask the rear of the target, making the target seem larger than it actually is. There is a similar effect for head-on targets, but the increase in the gunner's unsteadiness and the obscuration of the target may not be as large as for a side-on target. However, as shown in components 1 and 2, the range-measurement error for a head-on target is more sensitive to changes in the apparent separation of the stadia lines than with side-on targets. Thus, quite likely, the effects of head-on and side-on target motion can have identical effects.

There are range-measurement errors, in addition to the "normal" components, resulting from misuse of the stadia, and from targets at intermediate aspects between side-on and head-on. These range-measurement errors are shown in Figure 2A where, as in the previous figure, full-stadia ranging is shown on the left, and half-stadia ranging is shown on the right. Looking at "I" and "II" in the figure, we see that the effect of an error in selecting full- or half-stadia results in a large underestimate of range for a side-on target, and a large overestimate of range for a head-on target. Of the two, the misplacement of the head-on target (in the full-stadia) is the more frequent error. Another error that is made when positioning head-on targets in the stadia is shown in "IV." Here, the base of the target is incorrectly used in measuring the target range (as A\*), instead of the mid-section of the target, as shown at A in "IV" and "II".

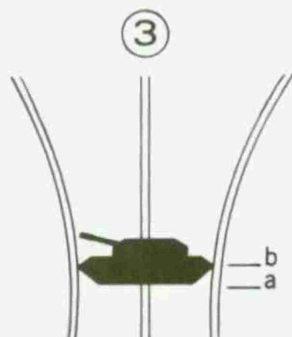
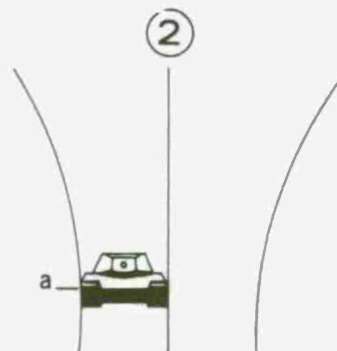


FULL-STADIA RANGING  
(SIDE-ON TARGET)

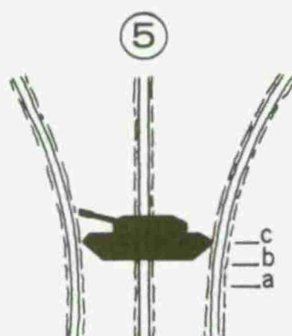
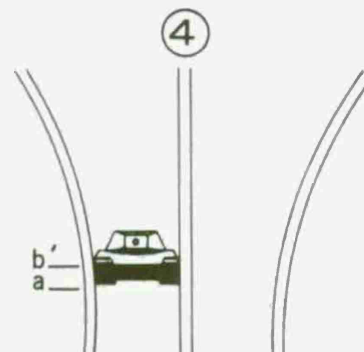


TRUE TARGET RANGE

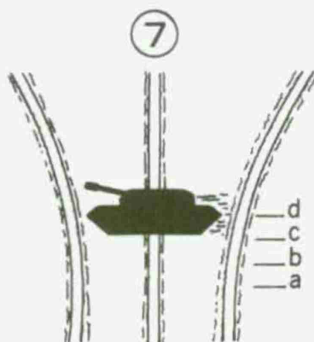
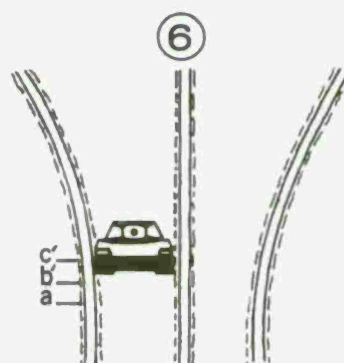
HALF-STADIA RANGING  
(HEAD-ON TARGET)



COMPONENT 1  
Caused by Stadia Line Thickness  
 $b-a < b'-a$



COMPONENT 2  
Caused by Gunner's Unsteadiness  
 $c-b < c'-b'$



COMPONENT 3  
Caused by Movement of Target  
 $d-c \neq d'-c'$

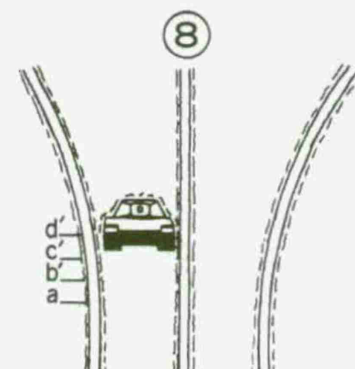
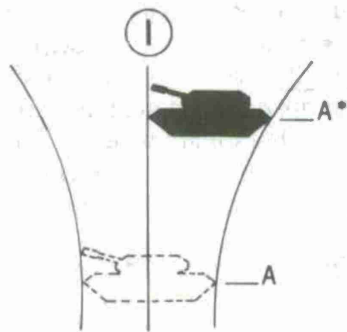


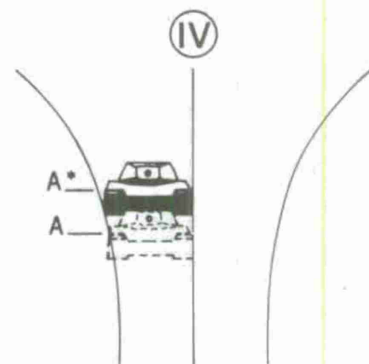
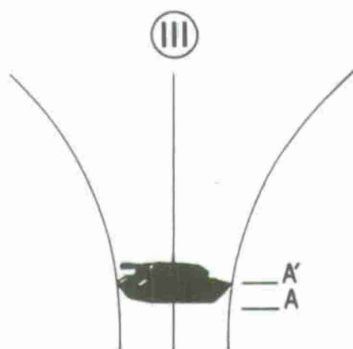
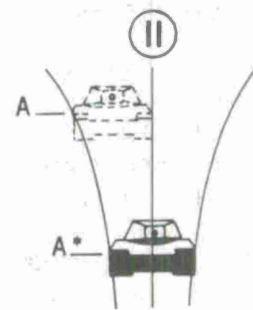
Figure 1A. Components of "normal" range measurement error using stadia.



### FULL-STADIA RANGING



### HALF-STADIA RANGING



### LEGEND

- A = True target range
- A\* = Incorrect range resulting when the target is incorrectly placed in the stadia
- A' = Incorrect range resulting when the target is correctly placed in the stadia

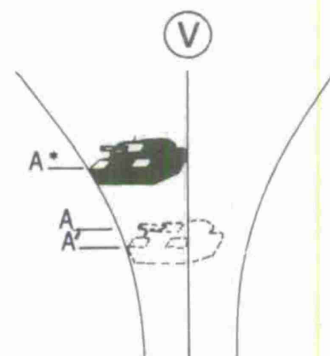


Figure 2A. Range-measurements errors resulting from (1) misuse of stadia and (2) targets at aspects other than head-on or side-on.

In a real encounter with a tank target, it is quite unlikely that the target will be exactly head-on or side-on. For this condition, if the apparent length is greater than the apparent width of the target, the full-stadia should be used to measure the target's range, and the entire target, as shown in "III," should be positioned between the stadia lines. As shown, this results in underestimating the target range when the target is correctly positioned in the stadia at A'. The decision processes are more difficult for targets that are nearly head-on than for those that are nearly side-on. Here, if the apparent width is greater than the apparent length of the target, the half-stadia is used to measure the target's range. But, unlike previous procedures, only the frontal portion of the target is fit into the half-stadia. Correct placement of the target, as shown in "V" results in an overestimate of the target range. However, it is quite likely that the target will be placed at either A\*, (shown in "V"), or at A\* (shown in "II"), depending on whether the target appears to be more nearly head-on or more nearly side-on.

To determine the overall errors for the conditions shown in Figure 2A, we add the errors shown in Figure 1A. If we now assume that the size of the target is different than the one for which the stadia are designed or that the target length-to-width ratio is not two-to-one, it is evident that other errors will also be incurred.

APPENDIX B

OPERATIONAL TEST OF M72A2 LAW

# DISPOSITION FORM

For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office.

REFERENCE OR OFFICE SYMBOL

AMXBR-IB

SUBJECT

Trip Report (CTO#1000), Operational Test of M72A2 LAW,  
Ft. Benning, GA, 21 May 1974

TO THRU: Chief, IBL

TO: Director

FROM BRL SMAWT Program

DATE 3 June 1974

CMT 1

First two paragraphs not relevant.

3. As planned, we reported directly to the North Ruth Range on Ft. Benning and were briefed on the activities to date by MAJ Sines. Significant items of interest from this review are contained in the following paragraphs.

a. Training of the 42 test soldiers had been completed. This training had consisted of a total of four hours which included two hours of "bleacher" or lecture-demonstration and two hours of firings at the Patton Range.

(1) The subjects were all graduates of Advanced Infantry Training but their previous LAW training was not known at the present. It might be possible to determine the extent of the previous training later but this is not certain.

(2) Each subject fired one M73, 35-mm Subcaliber Practice Rocket at a stationary APC (side presentation at a range of about 150 m) and two M73's at a moving (10 mph), manned, M60 tank (side presentation at a range from 125-225 m). It was required that each soldier get at least one hit out of these shots before firing an IIE, M72A2 LAW. All subjects met this requirement and then each fired an IIE, M72A2 LAW at a stationary M41 tank hull (16-ft long, side presentation at a range of 192 m). This M41 was located near where the M60 turned around at the 225-m position so the soldiers had this extra information about the range when firing from a standing position in a sandbagged foxhole. There were 34 hits and 8 misses (4 of these misses were very close) out of the 42 shots which is a hit probability of 0.8). From existing M72A2 LAW data, this level of performance is to be expected if the range estimation error is about 5 per cent rather than the usually expected standard deviation of 21 per cent.

(3) The Operational Test includes firing at targets out to 400 m and there are no formal procedures for firing beyond 350 m which is the last mark on the sight reticle. The subjects were told to aim high on the tank if they estimated the range to be "not much further than 350 m." They were told to pick out an object that is at a greater range and higher than the tank and to aim on it if they estimated the range to be "much further than 350 m."

b. Paired firings had been completed at the North Ruth Range which is the location to be used for all but the training. Twenty subjects each had fired two IIE, M72A2 LAW's at a stationary M46 tank hull (20-ft long, side presentation at a range of 206 m). This M46 was one of the targets (#1) positioned for use in subsequent tests (see Incl 2 for layout of North Ruth Range). The antitank rockets were fired from a standing position in a sandbagged foxhole (#10). The stadiametric rangefinder on the weapon was used to estimate the range. There were 22 hits and 18 misses out of the 40 shots which is a hit probability of 0.55. In the second part of this exercise with paired firings, 10 pairs of subjects were involved. One member of each pair fired an IIE, M72A2 LAW at the 206-m target. Using the range setting called out and the observed hit or miss, the other member of the pair fired. There were 13 hits and 7 misses out of the 20 shots which is a hit probability of 0.65. The overall results from the paired firings gave 35 hits and 25 misses out of 60 shots which is a hit probability of 0.58. The separate results for the first and second rounds in the pairs will be provided at a later date.



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21 May 1974

6. We spent our last 45 minutes at Ft. Benning interviewing five of the subjects after they had completed their firing for the day. Mr. Torre did most of the questioning to minimize the confusion. I'm sure that I wasn't able to document the questions and answers exactly but I believe the following paragraphs contain the substance of what we learned. The need to interview the subjects more thoroughly is clear.

a. Subject #1 was asked about his training. He said he determined the range to the stationary target to be 175 m (it was 192 m) by using the sight to verify the range that "everyone had heard beforehand". In the paired firings, he had estimated the range to be 200 m (it was 206 m) by using the sight and he hit the target. No further detail on paired firing was elicited. He had fired at the moving target in the tests just completed. His estimate of 175 m was reasonable and he claimed that he was told in advance that the target speed was 15 mph. This subject may have understood the use of the sight reticle as his estimates were good. However, he may have had more range information than the sight provided.

b. Subject #2 was questioned about training and said the range to the stationary target was 150 m (versus 192 m) estimated by "eyeball". He also said he got a hit. In the paired firings, he fired two shots. His first estimate was 200 m (versus 206 m) and his shot missed high. His second estimate was 150 m and he claimed a hit. In the latest tests, he used the sight to estimate 150-200 m and got a hit on a stationary tank hull. He used the sight to estimate 100-125 m on a pop-up panel but missed with the shot. This subject may or may not have understood the use of the sight reticle. He trusted his unaided visual estimation more.

c. Subject #3 said the range to the stationary target in training was estimated to be 225 m (versus 192 m) by use of the sight. He claimed a hit. He was questioned in detail about the use of the sight reticle for stationary and moving targets. Incl 3 contains the instructions I extracted from FM 23-33 for reference. The subject was certain that the tank picture was to be located between the two curved stadia lines when the target was stationary. The fact that the tank might be seen as a side view or head-on made no difference. On the other hand, if the tank was moving, the picture was to be located between the center vertical line and the appropriate curved stadia line. In the paired firings, his partner missed with an estimate of 200 m (versus 206 m) and he followed with a hit by using the sight to estimate 250 m. In the tests just completed, he used the half-reticle for the moving target, estimated 200 m, and got one hit in the two shots. This subject obviously did not understand the use of the sight reticle and the performances he claimed are to be considered in that context.

d. Subject #4 estimated the range to the stationary target in training by proper use of the sight reticle. However, he was certain that the sight was not to be used when the tank target is head-on. An "eyeball" estimate must be used in this case. In the paired firings, he estimated 200 m (versus 206 m) and hit

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with both shots. In the tests just completed, he was directed to fire at a tank hull and a panel which were side by side. He used a combination of "eyeball" and sight to estimate 200 m for the tank and hit both targets with this setting. This subject doesn't fully understand the use of the sight reticle.

e. Subject #5 used the sight to estimate the range to the stationary target in training to be 225 m (versus 192 m) and got a hit. He understood that half the reticle was to be used for range estimation with a head-on presentation and that the picture was to be centered to aim at the target. In the paired firings, he fired first with a 225 m (versus 206 m) estimate and hit. His partner followed with a hit at the same setting. This subject had not fired in the tests just completed. When questioned about the use of the reticle for moving targets, he gave some mixed up version of use of the lead marks. This subject also doesn't fully understand the use of the sight reticle.

3 Incls  
as

/s/  
JEROME M. FRANKLE

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Mr. J. P. Torre, HBL

## APPENDIX C

### TABLES OF RANGE MEASUREMENT ERRORS



TABLE 1C

Range Measurement Errors with the M72A2 Sight Mockup, Group 1

Target	Range Measurement Errors in Meters							
Number	1		2		3		4	
Range (meters)	295		200		350+		235	
Aspect	Side-on		Head-on		Side-on		Quartering	
Speed (mph)	0	15	0	15	0	15	0	15
Subject								
1	-20	5	-125	150	-25	-25	-10	-10
2	-70	-70	-150	-150	-75	-75	-210	-10
3	5	5	150	150	0	0	-10	-10
4	-30	5	50	50	-100	-150	15	15
5	-10	-145	-25	-25	0	0	-10	-5
6	-20	-20	125	100	-50	-50	-10	-10
7	-45	-20	150	150	-25	-25	-10	-10
8	5	5	0	0	0	0	40	40
9	5	5	0	0	0	0	5	5
10	-70	-20	125	125	-50	0	-10	-10
11	-45	-70	0	75	-25	-100	-10	-10
12	-70	-20	150	150	0	0	-10	-10
13	-95	-70	150	150	-75	-25	-10	-10
14	-45	-45	50	25	-100	-100	15	15
15	5	5	100	100	0	0	65	65
16	5	-145	0	-25	-150	-150	-10	-10
17	-45	-145	50	-100	-125	-175	40	-85
18	-70	-70	-25	-25	-75	-75	-10	-10
19	15	-20	150	150	0	0	-10	-10
20	5	5	0	0	0	0	-10	15
21	-20	-20	75	75	-100	-100	-85	-10
22	5	5	150	125	-25	0	-10	-10
23	-145	-95	0	0	-140	-200	-35	-85
24	-95	-145	-50	-100	-150	-150	-135	-135
25	-95	-145	150	50	-100	-150	-35	-185

TABLE 2C

Range Measurement Errors with the M72A2 Sight Mockup, Group 2

<u>Target</u>		<u>Range Measurement Errors in Meters</u>							
Number	Range (meters)	1		2		3		4	
		295		200		350+		235	
Aspect		<u>Side on</u>		<u>Head-on</u>		<u>Side-on</u>		<u>Quartering</u>	
Speed (mph)		<u>0</u>	<u>15</u>	<u>0</u>	<u>15</u>	<u>0</u>	<u>15</u>	<u>0</u>	<u>15</u>
<u>Subject</u>									
1		-5	5	-10	-10	0	0	0	-10
2		-5	-5	-15	-15	25	25	0	0
3		-70	-60	100	150	-50	-65	0	0
4		-60	-60	115	120	-75	-75	0	-10
5		-10	-10	-25	-25	0	0	-10	-10
6		-10	-10	-20	-25	0	0	10	15
7		5	5	-5	10	0	0	0	0
8		-5	-5	-10	-10	0	0	-60	-60
9		-5	-5	-15	-15	50	50	0	15
10		-30	-20	50	80	-50	-75	5	0
11		-15	-15	150	130	0	0	0	0
12		-10	-10	-10	-10	0	0	0	-10
13		-110	-110	-50	-65	-155	-225	-60	-110
14		-10	-10	-10	-10	25	25	-10	0
15		-10	-10	-10	-10	-10	-10	0	0
16		-25	-20	125	90	-25	0	-15	-10

TABLE 3C

## Range Measurement Errors with the M72A2 Sight Mockup - Group 3

<u>Target</u>		<u>Range Measurement Errors in Meters</u>															
Number		1		2		3		4		5		6		7		8	
Range (meters)		215		225		350+		280		210		160		100		320	
Aspect		<u>Side-on</u>		<u>Head-on</u>		<u>Side-on</u>		<u>Quar-</u>		<u>Frontal</u>		<u>Flanking</u>		<u>Flanking</u>		<u>Frontal</u>	
Speed (mph)		<u>0</u>	<u>15</u>	<u>0</u>	<u>15</u>	<u>0</u>	<u>15</u>	<u>0</u>	<u>15</u>	<u>0</u>	<u>15</u>	<u>0</u>	<u>15</u>	<u>0</u>	<u>15</u>	<u>0</u>	<u>15</u>
<u>Subject</u>																	
1		-5	0	-20	-10	50	50	-10	-5	-55	-60	-5	-5	-5	-5	-75	-65
2		0	10	0	105	-25	-25	-10	-20	105	120	15	0	10	0	30	5
3		10	10	25	-5	0	0	20	15	-35	35	15	15	0	0	-60	-70
4		5	10	5	0	50	50	15	20	-45	115	15	15	0	20	-20	-40
5		-10	-10	-15	-25	50	50	-15	-15	-65	-60	-5	0	0	0	-85	-85
6		0	10	0	0	0	0	20	10	-45	130	15	15	10	0	-55	-60
7		-20	-5	-25	-10	25	-140	-20	-20	-10	-10	-5	0	-10	-10	-15	-10
8		5	0	0	0	0	25	5	0	-60	115	0	0	5	-5	-60	-50
9		-5	0	-10	0	0	0	-5	0	5	-20	0	0	0	0	-30	-10
10		0	0	-10	-10	25	25	-10	-15	-55	110	0	5	-20	-25	-60	80
11		-10	-15	-75	-65	-25	-175	-65	-145	-65	-70	-10	-20	-25	-25	-120	-50
12		0	0	-10	-5	0	0	-5	0	-50	110	-5	5	0	0	-70	-70
13		10	10	80	75	-25	-25	5	5	115	115	-10	-10	30	5	5	5
14		5	0	-5	150	25	25	5	-15	-50	85	0	-10	-20	-25	-85	55
15		0	0	-15	-5	50	50	-20	0	-50	-60	0	5	10	10	-70	-70
16		-5	-5	-15	-15	0	0	-10	0	-60	-50	0	0	0	0	-75	-70
17		5	10	125	125	0	0	20	20	115	145	15	20	10	25	55	30
18		5	5	0	-5	0	0	0	0	-50	-50	-10	0	-10	0	-65	-60
19		-5	0	-10	10	50	50	-5	-5	-50	-50	0	0	0	0	-60	-55



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